


✓m (2)

AD-A242 732

REPORT DOCUMENTATION PAGE

| | | | | | |
|---|-------|---|--|--|--------------------------|
|  | | DTIC SELECTED NOV 13 1991 | | 1b RESTRICTIVE MARKINGS | |
| 2a SECURITY CLASSIFICATION AUTHORITY | | 2b DECLASSIFICATION/DOWNGRADING SCHEDULE | | 3 DISTRIBUTION/AVAILABILITY OF REPORT Unlimited | |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S) Final Report | | 5 MONITORING ORGANIZATION REPORT NUMBER(S) | | | |
| 6a NAME OF PERFORMING ORGANIZATION University of Southern California | | 6b OFFICE SYMBOL (If applicable) MC 1211 | | 7a NAME OF MONITORING ORGANIZATION Office of Naval Research | |
| 6c ADDRESS (City, State, and ZIP Code) Department of Chemical Engineering University of Southern California Los Angeles, California 90089-1211 | | 7b ADDRESS (City, State, and ZIP Code) 800 North Quincy Street Arlington, Virginia 22217-5000 | | | |
| 8a NAME OF FUNDING/SPONSORING ORGANIZATION ONR/DARPA | | 8b OFFICE SYMBOL (If applicable) | | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER ONR N00014-88-K-0302 | |
| 8c ADDRESS (City, State, and ZIP Code) 800 North Quincy Street Arlington, Virginia 22217-5000 | | 10 SOURCE OF FUNDING NUMBERS | | | |
| | | PROGRAM ELEMENT NO | | PROJECT NO | TASK NO |
| | | | | | WORK UNIT ACCESSION NO |
| 11 TITLE (Include Security Classification) The Behavior of Polymers Filled with Monodisperse Polymeric Beads | | | | | |
| 12 PERSONAL AUTHOR(S) R. Salovey and J. J. Aklonis | | | | | |
| 13a TYPE OF REPORT Final | | 13b TIME COVERED FROM 5/1/88 to 8/14/91 | | 14 DATE OF REPORT (Year, Month, Day) 1991, November 4 | |
| 15 PAGE COUNT 3 | | | | | |
| 16 SUPPLEMENTARY NOTATION | | | | | |
| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) | | |
| FIELD | GROUP | SUB-GROUP | Filled Polymers; Crosslinked Monodisperse Polymeric Beads; Rheology | | |
| | | | | | |
| 19 ABSTRACT (Continue on reverse if necessary and identify by block number) --Project Summary attached-- | | | | | |
| 20 DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS | | | | | |
| 21 ABSTRACT SECURITY CLASSIFICATION Unclassified | | | | | |
| 22a NAME OF RESPONSIBLE INDIVIDUAL Dr. Joann Milliken | | | 22b TELEPHONE (Include Area Code) (703) 696-4409 | | 22c OFFICE SYMBOL ONR |

91-15819



The Behavior of Polymers Filled with Monodisperse Polymeric Beads

Grant/Contract N00014-88-K-0302, R&T code 413m010

Ronald Salovey and John J. Aklonis, Principal Investigators

**Departments of Chemical Engineering and Chemistry
University of Southern California
Los Angeles, California 90089-1211**

FINAL REPORT

Techniques have been developed for preparing crosslinked spherical polymer beads, monodisperse in size, composed of polystyrene and derivatives, polymethyl methacrylate (PMMA), polyethyl methacrylate, polybutyl methacrylate and polymethylacrylonitrile [1-3]. Control of the crosslink density gradient was achieved by semi-continuous copolymerization [4, 5]. Monodisperse bead diameters are controlled between 150-800 nm in a single stage synthesis, with sizes reproducible to ± 5 nm in a given run and crosslink densities vary from 1-20 mol%. Particle nucleation onto preexisting polymer seeds was conducted in a multistage polymerization yielding compositionally complex beads up to 4 μ m in diameter [6].

Beads are characterized by a wide variety of techniques. A new procedure has been developed to determine the crosslink density by equilibrium swelling on an ultrafiltration membrane [4].

Techniques for mixing polymer beads and polymer matrices have been developed [7]. The rheological properties of polymeric composites, of beads and matrices, are often insensitive to the size and crosslink density of the beads [8]. Rheological changes are particularly sensitive to chemical composition in a polar matrix. In general, reduced rheological increases are realized for composites in which bead and matrix are compatible [9, 10]. The steady shear viscosity of composites, consisting of a PMMA matrix, filled with 20% of crosslinked beads of varied composition, exhibits time dependent increases on aging following shearing [10].

Changes in steady shear viscosity and dynamic moduli depend on the dispersion of particles in a polymeric matrix. Incompatible particles form large clusters, which are destroyed at high shear rate, producing a highly non-Newtonian response. Clusters reform rapidly on aging at elevated temperatures. For compatible composites, crosslinked particles are randomly dispersed on mixing and remain so on aging, producing (almost) Newtonian behavior.

| | |
|---------------|--|
| Accession For | |
| DTIC GRAFI | |
| DTIC TAB | |
| Unannounced | |
| Justification | |
| By | |
| Distribution | |
| Availability | |
| DTIC | |
| A-1 | |

Technical Reports and Journal Articles

1. D. Zou, V. Derlich, K. Gandhi, M. Park, L. Sun, D. Kriz, Y. D. Lee, G. Kim, J. J. Aklonis and R. Salovey, "Model Filled Polymers I. Synthesis of Crosslinked Monodisperse Polystyrene Beads," *J. Polym. Sci.: Part A: Polym. Chem.*, **28**, 1909-1921 (1990).
2. D. Zou, S. Ma, R. Guan, M. Park, L. Sun, J. J. Aklonis and R. Salovey, "Model Filled Polymers V. Synthesis of Crosslinked Monodisperse Polymethacrylate Beads," *J. Polym. Sci.: Polym. Chem.*, in press (1991).
3. D. Zou, J. J. Aklonis and R. Salovey, "Model Filled Polymers XI. Synthesis of Monodisperse Crosslinked Polymethacrylonitrile Beads," *J. Polym. Sci.: Polym. Chem.*, submitted (1991).
4. Z.-Y. Ding, J. J. Aklonis and R. Salovey, "Model Filled Polymers VI. Determination of the Crosslink Density of Polymeric Beads by Swelling," *J. Polym. Sci.: Part B: Physics*, **29**, 1035-1038 (1991).
5. Z.-Y. Ding, S. Ma, D. Kriz, J. J. Aklonis and R. Salovey, "Model Filled Polymers IX. Synthesis of Uniformly Crosslinked Polystyrene Microbeads," *J. Polym. Sci.: Polym. Phys.*, submitted (1991).
6. D. Zou, L. Sun, J. J. Aklonis and R. Salovey, "Model Filled Polymers VIII. Synthesis of Crosslinked Polymeric Beads by Seed Polymerization," *J. Polym. Sci.: Polym. Chem.*, in press (1991).
7. K. Gandhi, M. Park, L. Sun, D. Zou, C. X. Li, Y. D. Lee, J. J. Aklonis and R. Salovey, "Model Filled Polymers II., Stability of Polystyrene Beads in a Polystyrene Matrix," *J. Polym. Sci.: Part B: Polym. Phys.*, **28**, 2707-2714 (1990).
8. M. Park, K. Gandhi, L. Sun, J. J. Aklonis and R. Salovey, "Model Filled Polymers III. Rheological Behavior of Polystyrene Containing Crosslinked Polystyrene Beads," *Polym. Eng. and Sci.*, **30**, 1158-1164 (1990).
9. L. Sun, M. Park, J. J. Aklonis and R. Salovey, "Model Filled Polymers VII. Flow Behavior of Polymers Containing Monodisperse Crosslinked Polymeric Beads," *Polym. Eng. and Sci.*, in press (1991).
10. L. Sun, M. Park, J. J. Aklonis and R. Salovey, "Model Filled Polymers XIII. Mixing and Time-Dependent Rheological Behavior of Polymer Melts Containing Crosslinked Polymeric Particles," *Polym. Eng. and Sci.*, submitted (1991).

Personnel Who Participated in the Research

| | |
|-----------------|--------------------------|
| Valerie Derlich | - graduate student |
| Ruiling Guan | - graduate student |
| Gia Y. Kim | - graduate student |
| Dennis Kriz | - graduate student |
| Hemant Manohar | - graduate student |
| Moonsoo Park | - graduate student |
| Abhay Sawant | - graduate student |
| Liqing Sun | - graduate student |
| Min Wei Chen | - visiting scholar |
| Zheng-You Ding | - visiting scholar |
| Guoshu He | - visiting scholar |
| Shen Min Ma | - visiting scholar |
| Dezhong Zou | - visiting scholar |
| Fute Chen | - visiting scholar |
| Khushroo Gandhi | - post-doctoral fellow |
| Young D. Lee | - post-doctoral fellow |
| Cheng-Xue Li | - post-doctoral fellow |
| John J. Aklonis | - principal investigator |
| Ronald Salovey | - principal investigator |